Improving the evaluation of cardiac function in rats at 7T by using non-local means filtering.

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Abstract 45651

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Purpose / Introduction

Multi-element cardiac coil arrays are often required for signal reception to attain high-quality images of the rat heart [1]. These coils are not yet widely available. We investigated the effect of the non-local means filter [2] on lower quality cardiac cine-MR images, particularly on the accuracy and the variability of cardiac function parameters.

Subjects and Methods

Nine rats (n=9) were scanned using a 7T Varian scanner, with a 63mm-diameter volume coil. Series of short-axis cine images covering the left ventricle were obtained with an ECG and respiratory-gated cine-FLASH sequence (in plane resolution: 195x195µm2 ; slice thickness : 1mm ; 16 frames).
Hearts were excised after image acquisition, and the left ventricle mass (LVM) was determined by ex vivo measurement of the weight of the heart.
Each 3D image of the cardiac cycle was denoised using non-local means filtering with automatic noise standard deviation estimation of the background, search volume of 1331 neighbors and neighboring size of 26 neighbors [2] (Figure 1).
Cine images were manually segmented using Segment , twice by the same observer, and by two different observers. The end-diastolic and end-systolic volumes (EDV, ESV), the ejection fraction (EF) and the LVM were calculated. A two-tailed paired Student's t-test was used to determine any significant differences between measurements from different segmentations (p<0.05).

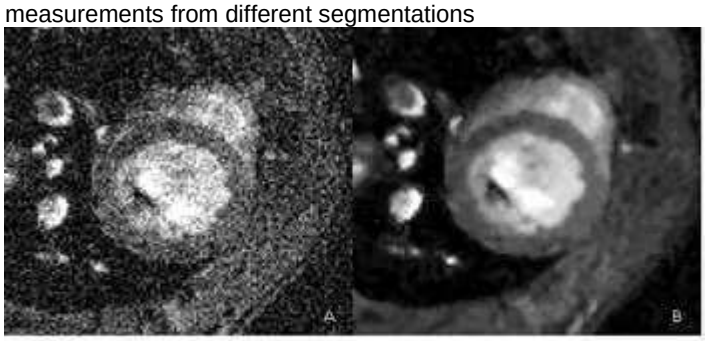

Figure 1 – Short-axis image of the rat heart A) acquired from the MR scanner (non-denoised) B) after non-local means filtering (denoised). Contrast-to-noise ratio (CNR) was 7±2 for non-denoised images and 23±8 for denoised images.

Results

There was a good agreement between values of the LVM from ex vivo measurements and from manual segmentation of both sets of images (Table 1). Significant differences were found for observer B with the non-denoised images whereas there were no significant differences with the denoised images.
Intra-observer variability (Table 2) was small in general with both datasets with the exception of ESV and no significant differences were found. The variability decreased for every parameter with the denoised images.

The inter-observer variability decreased for all the parameters with the denoised images except for the EDV.

	Non-denoised images			Denoised images		
	Mean difference (mg)	Relative difference (%)	r	Mean difference (mg)	Relative difference (%)	r
Observer A	-1.8 ± 22.4	-0.6 ± 4.5	0.99	1.8 ± 21.3	0.6 ± 3.6	0.99
Observer B	28.6 ± 32.8*	4.5 ± 5.7	0.98	22.9 ± 34.0	3.3 ± 5.5	0.99

Table 1 – Mean values ± standard deviation (SD) and correlation coefficient *r* for the comparison of LVM obtained from ex-vivo measurement and from the segmentation of cine images. *$p<0.05$

	Non-denoised images		Denoised images	
	Mean difference	Relative difference (%)	Mean difference	Relative difference (%)
Intra-observer				
EDV (µL)	-2.1 ± 15.0	-0.4 ± 3.7	4.7 ± 14.9	1.1 ± 3.1
ESV (µL)	-5.3 ± 15.4	-5.2 ± 12.8	-2.8 ± 11.6	-1.4 ± 7.7
EF (%)	1.2 ± 2.8	1.7 ± 3.9	0.5 ± 2.0	0.6 ± 2.7
LVM (mg)	13.9 ± 30.3	1.6 ± 4.2	-4.4 ± 27.7	-0.3 ± 4.6
Inter-observer				
EDV (µL)	28.8 ± 9.7*	5.5 ± 2.1	27.11 ± 25.72*	5.4 ± 5.0
ESV (µL)	21.4 ± 21.9*	12.4 ± 13.1	14.2 ± 18.0*	8.2 ± 11.1
EF (%)	-1.9 ± 4.0	-2.7 ± 5.7	-0.7 ± 2.7	-1.0 ± 3.7
LVM (mg)	1.0 ± 39.9	0.6 ± 6.6	27.3 ± 40.2	3.2 ± 5.6

Table 2 – Intra and inter-observer variability for manual segmentation of non denoised images and denoised images. ***p<0.05***

Discussion/Conclusion

Each observer had to determine the most basal slice to include in the analysis, resulting in significant differences for EDV and ESV. Overall, intra and inter-variability of cardiac function parameters were reduced with the denoised images, comparing well with results from previous reports [1,3]. Denoising could be an interesting alternative to the need of better contrast between myocardium and surrounding tissues. The influence of denoising on semi-automatic segmentation will be the object of future work.

References

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